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WEAR INVESTIGATIONS ON TIMING CHAINS USING A CHAIN JOINT TRIBOMETER

TRACK OR CATEGORY

5J Engine & Drivetrain V

AUTHORS AND INSTITUTIONS

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INTRODUCTION

The lifetime of timing chains is determined by the wear in the chain joints. Due to contact forces and sliding motion, the pin and the bush of the chain joints are worn out. The influences on the chain wear are highly complex, from basic aspects like the chain geometry and the lubrication up to the surface treatment. In order to investigate these influences systematically, several experimental and analytical tools are used. Recently a new home-made test rig, called chain joint tribometer, was developed and realized. This tool allows for friction and wear investigations on one single chain joint. Therefore, the real contact situation is reproduced using batch production components. The load curves and the relative motion between pin and bush are applied to the chain joint with highly dynamic actuating elements.

CHAIN WEAR TEST RIG

To conduct wear investigations with well-defined operating conditions that are close to the real conditions in the application of the chain, a chain wear test rig was developed. This test rig can be used for different chain types such as roller, bush and silent chains. To allow for a wide range of different operating conditions, the test rig is designed to be as modular as possible. The test rig configuration for wear investigations is shown in Figure 1. In this setup, the torque is applied mechanically between two chains by a self-developed tension clutch [1]. The torque load is measured with resistance strain gauges that are applied to rear shaft. Furthermore, a shaft center distance varying mechanism was implemented, which allows for adjusting the shaft center distance by ±0,2 mm (load torque ±15%) during the test rig operation. Thus, the drop in the torque load value as a result of chain elongation can be adjusted without stopping the test run. An oil supply unit is used to lubricate the chains. The oil can be heated up and it is possible to use the oil with engine soot. More detailed information about the test rig can be found in [1, 2].

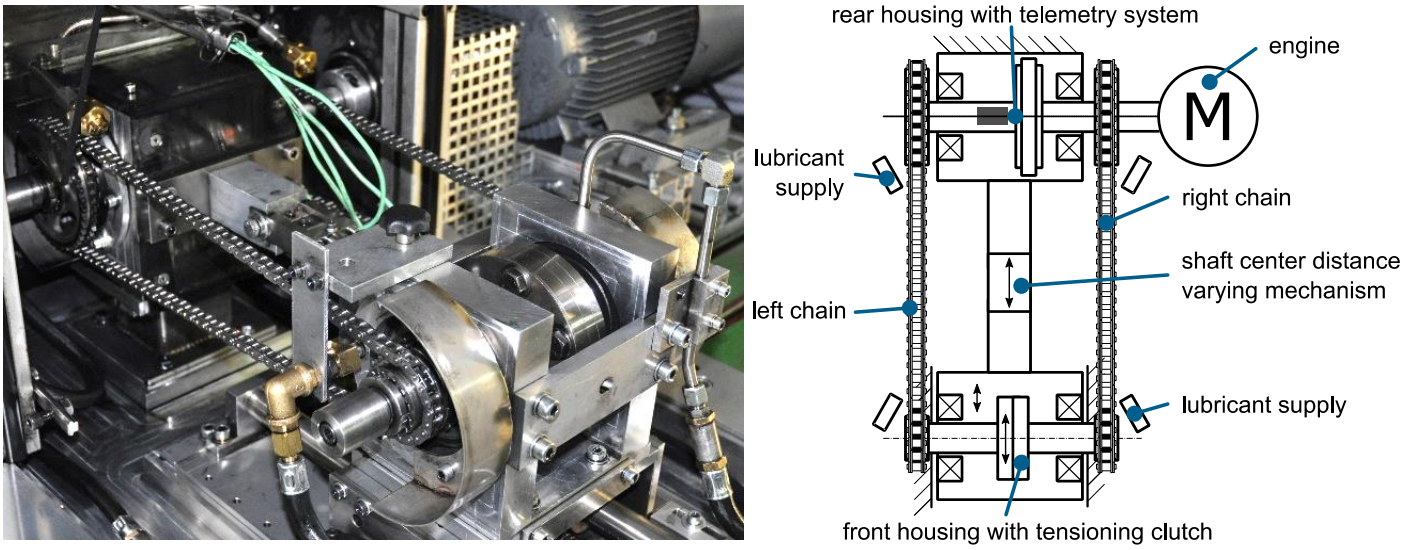

Figure 1: Modular chain wear test rig for operating chains with defined conditions

Chain Joint Tribometer

As a supplement to the chain wear test rig a new unique chain joint tribometer was developed and built up. The main goal of this tribometer is to apply all possible internal loads that act in a chain on a single chain joint. The outer link of the test pin is mounted with special adapters between two shafts. Each shaft is supported by a bearing support which are mounted on the test rig's base plate. A variation of the distance between the housings enables for testing various kinds of chains sizes. A highly dynamic electrical engine is attached to the drive shaft which provides the swivel movement or in an alternative setup a simple rotational movement into the system. To absorb the radial forces a secondary shaft is used. To complete the test chain joint, the bush is mounted with the inner link and an adapter to an electrical linear motor. This high dynamic engine provides the normal force to the test chain joint. For the swivel movement and the contact force, results of a MBS model of the chain wear test rig are used as input data for the actuators. Due to the applied load and the sliding motion, material is removed from both the pin and the bush which leads to an increased clearance and an elongation of the chain segment. To detect the wear elongation, the variation of the distance between a defined fixed point on the adapter of the chain segment to the surfaces of both shafts is measured by eddy current sensors. Furthermore, the friction torque in the chain joint is measured indirectly by a 3-component dynamic force sensor. An oil supply unit is used to lubricate the chain components. The oil can be heated up and it is possible to use oil with engine soot. Furthermore, the position where the oil is applied can be freely adjusted and the amount of oil injected to the test chain joint is measured and adjustable in a wide range.

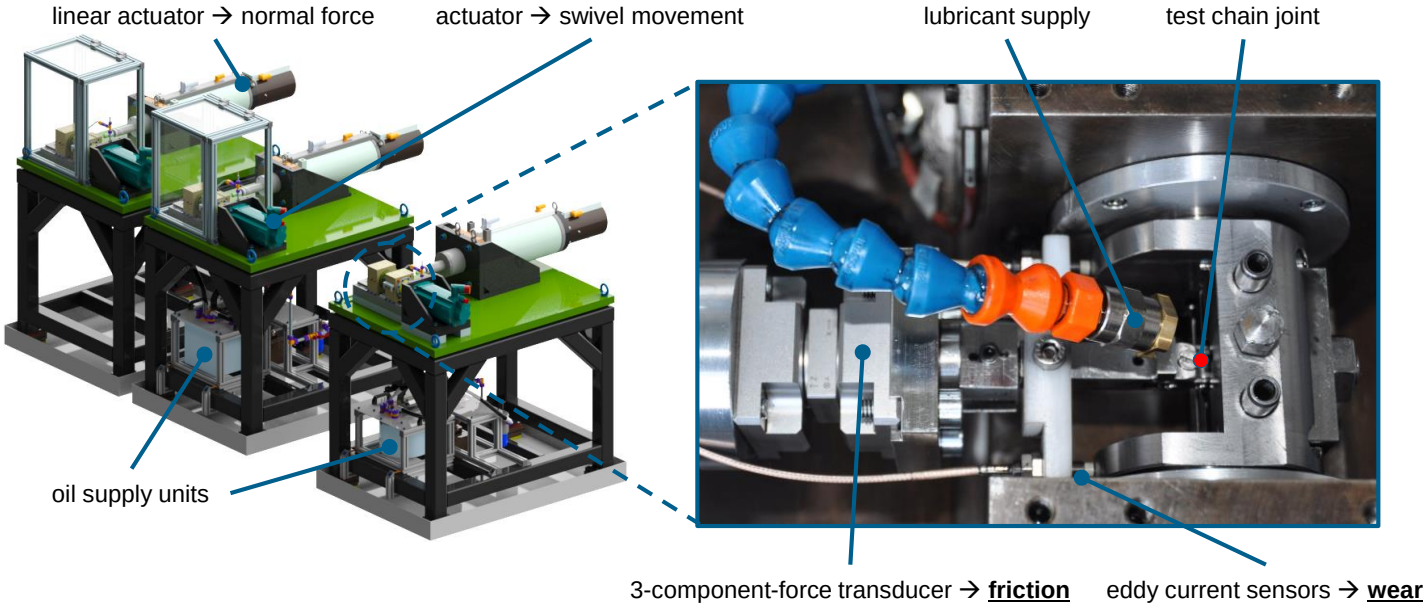

Figure 2: Chain joint tribometer: Wear and friction investigations on single chain joints

Wear measurement devices

The easiest way to detect the wear is measuring the length of the chain which is done with a self-developed device. With the chain length, the wear elongation at specific runtimes is obtained. The wear elongation is only a mean value for the whole chain or for a section of the chain. To get more detailed information of the wear distribution between pin and bush and on each of the components, a standard roundness measuring instrument is used to measure the inner contour of the bush and the outer contour of the pin. The roundness is measured on several planes for each component. As the software of the instrument is only able to derive standard roundness parameters, a self-developed postprocessing is conducted with the raw measurement data. More detailed information about the wear measurement devices can be found in [2-5].

First Results

After successful initial operation of the chain joint tribometer a comparative wear investigation to the chain wear test rig was made. The tested chains were bush chains with a pitch of 8 mm. As a first step, a test run with two chains on chain wear test rig with low speed (500 rpm) and a load of 40 Nm was conducted. A PAO with a simple additive package and 1 wt% engine soot was used for both tests to lubricate the chains. At specific runtimes the test rig was stopped to remove the chains and measure the wear elongation with the length measurement device. For the comparative test run on the chain joint tribometer an idealized load collective was used. The test chain joint was swiveled between -10°

and +10° by a sinus signal with a frequency of 10 Hz and a constant load of 250 N. During the test run the wear elongation curve was measured by the two eddy current sensors without stopping the test rig. After both test runs were finished the roundness measurement device was used to measure the outer contour of the pins and the inner contour of the bushes. Figure 3 shows the results of the wear elongation and the roundness measurement for both the chain wear test rig and the chain joint tribometer. The results have good accordance regarding the wear elongation curve, in particular the stationary wear rate, the angle and the wear depth of the single components.

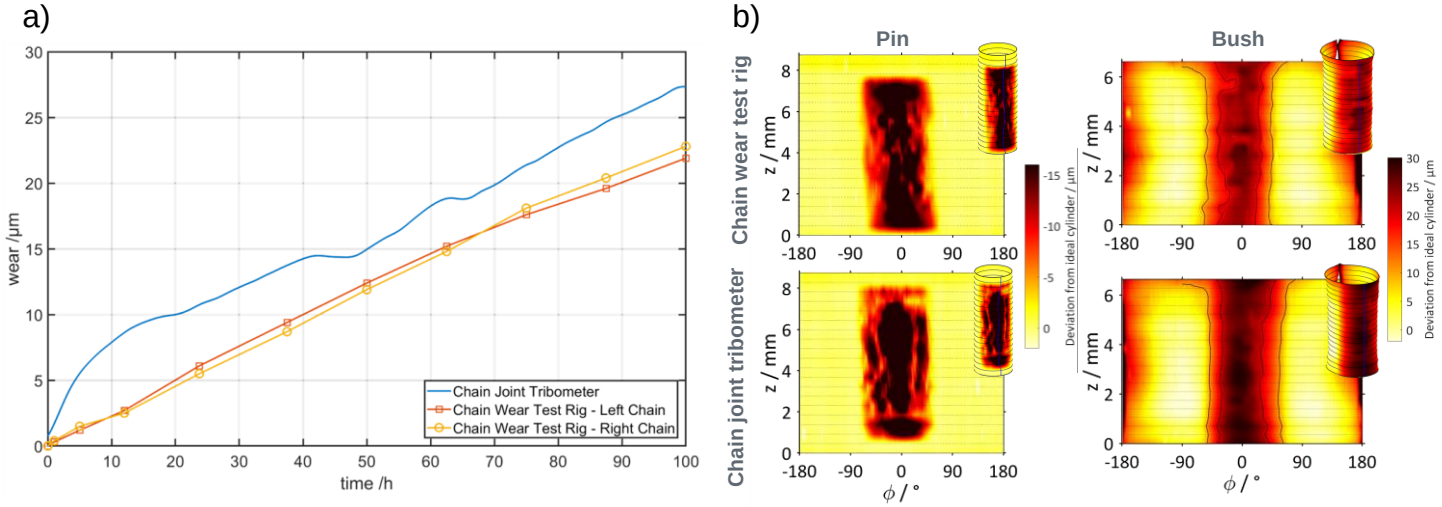

Figure 3: a) Wear elongation over time; b) Results of roundness measurements on pin and bush after 100 h runtime

OUTLOOK

In this paper the experimental methods used for investigating chain wear at MEGT have been presented. The presented results show, that there is a high potential for using the chain joint tribometer as a supplement to the chain wear test rig to get more detailed information about the tribological contact situation in chains joints. In the future, the chain joint tribometer will be used to investigate the friction and wear on batch production components as well as components with a modified surface to improve the friction and wear behavior .

ACKNOWLEDGMENTS

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KEYWORDS

Chain Drives, Wear Mechanisms, Wear/Failure Testing Devices